U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

A

UTILITY PATENT APPLICATION TRANSMITTAL LETTER UNDER 37 C.F.R. 1.53(b)	ATTORNEY DOCKET NO.: **10517/4**

Address to:
Assistant Commissioner for Patents
Washington D.C. 20231
Box Patent Application

Transmitted herewith for filing is a patent application.

Inventor(s): **Tomojiro SUGIMOTO and Keiso TAKEDA**

For: **FUEL INJECTION VALVE FOR AN INTERNAL COMBUSTION ENGINE**

1. Enclosed are:

- [X] 14 sheet(s) of drawing(s)
- [X] An Assignment of the invention to Toyota Jidosha Kabushiki Kaisha
- [X] A certified copy of Japanese application no.(s) 9-167629 and 9-310500 on which the claim to priority is based
- [X] A declaration/power of attorney
- [X] An Information Disclosure Statement along with copies of the cited references

2. The filing fee has been calculated as shown below:

	NUMBER FILED	NUMBER EXTRA*	RATE ($)	FEE ($)
BASIC FEE				790.00
TOTAL CLAIMS	3- 20 =		22.00	0.00
INDEPENDENT CLAIMS	1- 3=		82.00	0.00
MULTIPLE DEPENDENT CLAIM PRESENT			270.00	0.00
*Number extra must be zero or larger			TOTAL	790.00
If the applicant is a small entity under 37 C.F.R. §§ 1.9 and 1.27, then divide total fee by 2, and enter amount here.			SMALL ENTITY TOTAL	

Express Mail No. EM360782696US

3. Please charge the required application filing fee of $790.00 to the deposit account of **Kenyon & Kenyon**, deposit account number **11–0600**.

4. The Commissioner is hereby authorized to charge payment of any fees associated with this communication or arising during the pendency of this application, with the exception of the Issue Fee, or to credit any overpayment, to the deposit account of **Kenyon & Kenyon**, deposit account number **11–0600**.

5. When payment of any Issue Fee under 37 C.F.R. § 1.18 and/or Post Issuance Fee under 37 C.F.R. § 1.20 has previously been expresly authorized, the Commissioner is hereby authorized to charge payment of any deficiency in these fees to the deposit account of **Kenyon & Kenyon**, deposit account number 11-0600.

6. A duplicate copy of this letter is enclosed for that purpose.

Respectfully submitted,

Dated: June 9, 1998

By: _____
Patrick J. Fay
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TITLE OF THE INVENTION

FUEL INJECTION VALVE FOR AN INTERNAL COMBUSTION ENGINE

INCORPORATION BY REFERENCE

The disclosure of Japanese Patent Application No. HEI 9-169007 filed on June 25, 1997 including the specification, drawings and abstract is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates to a fuel injection valve for an internal combustion engine.

BACKGROUND OF THE INVENTION

A fuel injection valve for an internal combustion engine equipped with a fuel jet adjusting plate for atomizing injected fuel is conventionally known. The fuel jet adjusting plate has nozzle holes arranged along circles coaxial with a central axis of a valve body. This type of fuel injection valve for an internal combustion engine is disclosed, for instance, in Japanese Patent Application Laid-Open No. HEI 7-127550. This technology employs a large number of nozzle holes arranged along two circles coaxial with the central axis of the valve body.

Fig. 6 is a partial plan view of the fuel jet adjusting plate of the conventional fuel injection valve for an internal combustion engine. Referring to Fig. 6, reference character L0' denotes the central axis of the valve body, C1' a first circle coaxial with the central axis L0' C2' a second circle coaxial with the central axis L0' and having a diameter larger than that of the first circle, H1' first nozzle holes arranged at predetermined intervals along the first circle C1', and H2' second nozzle

holes arranged at predetermined intervals along the second circle C2'. Fig. 7 is a sectional view taken along line VI-VI in Fig. 6. Referring to Fig. 7, reference character 1' denotes the fuel jet adjusting plate, F1' fuel spray injected through the first nozzle holes H1', F2' fuel spray injected through the second nozzle holes H2', D1' a diameter of the first nozzle holes H1', and D2' a diameter of the second nozzle holes H2'. As can be seen from Figs. 6 and 7, fuel flows toward the central axis L0' in a radially outside-to-inside direction as indicated by blank arrows and is then injected through the nozzle holes H1', H2'. The fuel jet adjusting plate atomizes the fuel thus injected.

However, the flow rate of fuel becomes higher in the radially outside-to-inside direction. Thus, if the diameter D1' of the first nozzle holes H1' is equal to the diameter D2' of the second nozzle holes H2', the fuel spray F2' injected through the second nozzle holes H2' is not atomized as suitably as the fuel spray F1' injected through the first nozzle holes H1'. In this case, the fuel spray F2' has a large particle diameter and may even take the shape of a column as illustrated in Fig. 7. Thus, it is impossible to suitably atomize the fuel spray F2', whereby the performance of an internal combustion engine on which the fuel injection valve is mounted deteriorates.

SUMMARY OF THE INVENTION

The present invention has been devised in consideration of the aforementioned problems. It is thus an object of the present invention to provide a fuel injection valve capable of preventing deterioration of an internal combustion engine on which the fuel injection valve is mounted by suitably atomizing both fuel spray injected through radially outside nozzle holes and fuel spray injected through radially inside nozzle holes.

In order to achieve the aforementioned object, a

first aspect of the present invention provides a fuel injection valve for an internal combustion engine including a valve body driven by a driving device between an open position and a closed position, a fuel jet adjusting plate for atomizing fuel injected when the valve body assumes the open position, a plurality of first nozzle holes formed in the fuel jet adjusting plate and arranged along a first circle coaxial with a central axis of the valve body, and a plurality of second nozzle holes formed in the fuel jet adjusting plate arranged along a second circle coaxial with the central axis and having a diameter larger than that of the circle, the second nozzle holes having an opening area smaller than that of the first nozzle holes.

In the first aspect of the present invention, the first nozzle holes arranged along the first, inner circle have an opening area larger than that of the second nozzle holes arranged the second, outer circle diameter. Thus, despite the fact that fuel flows at a lower rate upstream of the inlet portions of the second nozzle holes as compared to that upstream of the inlet portions of the first nozzle holes, it is possible to suitably atomize both the fuel spray injected through the first nozzle holes and the fuel spray injected through the second nozzle holes. Hence, preventing deterioration of the performance of an internal combustion engine on which the fuel injection valve is mounted.

In addition to the features of the first aspect of the present invention, a second aspect thereof proposes that an angle formed between hole axes of the first nozzle holes and a plane of the fuel jet adjusting plate be different from an angle formed between hole axes of the second nozzle holes and the plane of the fuel jet adjusting plate. Thus, the fuel spray injected through the first nozzle holes and the fuel spray injected through the second nozzle holes splash in different directions. As a result, it is possible to stabilize the fuel spray injected through the respective nozzle holes and suitably atomize

the injected fuel.

In addition to the features of the second aspect of the present invention, a third aspect thereof proposes that an acute angle formed between the hole axes of the second nozzle holes and a plane perpendicular to the central axis be smaller than an acute angle formed between the hole axes of the first nozzle holes and the plane perpendicular to the central axis.

In the third aspect of the present invention, the fuel spray injected through the first nozzle holes is directed away from the fuel spray injected through the second nozzle holes. Therefore, the fuel spray injected through the first nozzle holes does not interfere with the fuel spray injected through the second nozzle holes. As a result, it is possible to stabilize the fuel spray injected through the respective nozzle holes and suitably atomize the injected fuel.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects, features and advantages of the present invention will become apparent from the following description of preferred embodiments with reference to the accompanying drawings, wherein:

Fig. 1 is a partial plan view of a fuel jet adjusting plate of a fuel injection valve for an internal combustion engine according to a first embodiment of the present invention;

Fig. 2 is a sectional view taken along line II-II in Fig. 1;

Fig. 3 is a partial sectional view of the fuel injection valve for an internal combustion engine of the first embodiment;

Fig. 4 is a partial plan view of the fuel injection valve according to a second embodiment of the present invention;

Fig. 5 is a sectional view taken along line IV-IV in

Fig. 4;

Fig. 6 is a partial plan view of a fuel jet adjusting plate of a conventional fuel injection valve for an internal combustion engine; and

Fig. 7 is a sectional view taken along line VI-VI in Fig. 6.

DESCRIPTION OF PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will hereinafter be described with reference to the accompanying drawings. Fig. 1 is a partial plan view of a fuel jet adjusting plate of a fuel injection valve for an internal combustion engine according to a first embodiment of the present invention, the fuel jet adjusting plate having nozzle holes arranged along two circles coaxial with a central axis of a valve body. Referring to Fig. 1, reference character L0 denotes the central axis of the valve body, C1 a first circle coaxial with the central axis L0, C2 a second circle coaxial with the central axis L0 and having a diameter larger than the first circle, H1 first nozzle holes arranged at predetermined intervals along the first circle C1, and H2 second nozzle holes arranged at predetermined intervals along the second circle C2. Fig. 2 is a sectional view taken along line II-II in Fig. 1. Referring to Fig. 2, reference character 1 denotes a fuel jet adjusting plate, F1 fuel spray injected through the first nozzle holes H1, F2 fuel spray injected through the second nozzle holes H2, D1 a diameter of the first nozzle holes H1, and D2 a diameter of the second nozzle holes H2. Fig. 3 is a partial sectional view of a fuel injection valve for an internal combustion engine according to this embodiment, the fuel jet adjusting plate 1 being attached to the fuel injection valve. Referring to Fig. 3, reference character 2 denotes the valve body and reference character 3 a valve seat.

As can be seen from Fig. 3, the valve body 2 is disposed above the fuel jet adjusting plate 1 and driven by

driving means (not shown) between an open position and a closed position. When the valve body 2 assumes the open position, fuel supplied from top to bottom in Fig. 2 reaches a location immediately upstream of the fuel jet adjusting plate 1 and flows toward the central axis L0, that is, in a radially outside-to-inside direction (See blank arrows in Fig. 2). In this case, the fuel flows toward the central axis L0 at a lower rate upstream of inlet portions of the nozzle holes H2 than upstream of inlet portions of the nozzle holes H1. That is, the flow rate of fuel becomes higher in the radially outside-to-inside direction.

Taking such characteristics into account, the fuel jet adjusting plate 1 of this embodiment has the nozzle holes H1 arranged along the first circle C1 and nozzle holes H2 arranged along the second circle C2. The diameter D2 of the second nozzle holes H2 is smaller than the diameter D1 of the first nozzle holes H1.

Thus, despite the fact that fuel flows toward the central axis L0 at a lower rate upstream of inlet portions of the nozzle holes H2 than upstream of inlet portions of the nozzle holes H1, the fuel jet adjusting plate 1 can suitably atomize the fuel spray F1 injected through the first nozzle holes H1 and the fuel spray F2 injected through the second nozzle holes H2 without inhibiting fuel flow upstream of the inlet portions of the nozzle holes H1. Hence, deterioration of the performance of an internal combustion engine on which the fuel injection valve is mounted can be prevented, whereby the amount of HC emissions can be reduced.

Although the nozzle holes H1, H2 in the aforementioned embodiment have substantially circular cross section, those skilled in the art will understand that these holes H1, H2 may alternatively have a cross section of any other shape. Instead of setting the diameter D2 of the second nozzle holes H2 smaller than the diameter D1 of the first nozzle holes H1, an opening area of the nozzle holes H2 need only be smaller than that of the nozzle holes H1. Although the total number of the nozzle holes H1, H2 arranged along the circles C1, C2

in the aforementioned embodiment is twelve, the number of the nozzle holes provided is not specified. The invention only requires that a plurality of nozzle holes be arranged along two or more circles.

Fig. 4 is a partial plan view of a fuel injection valve according to a second embodiment of the present invention with a fuel jet adjusting plate obtained by making modifications to that of the first embodiment. Fig. 5 is a sectional view taken along line IV-IV in Fig. 4. In Figs. 1, 2, 4 and 5, like components or parts are denoted by like reference characters. Referring now to Figs. 4 and 5, a plane that is perpendicular to the central axis L0 is defined as a reference plane SB. The cross section as illustrated in Fig. 5 consists of a plane S0 perpendicular to the reference plane SB and including the central axis L0, planes S1 perpendicular to the reference plane SB and including respective hole axes L1 of the nozzle holes H1, and planes S2 perpendicular to the reference plane SB and including respective hole axes L2 of the nozzle holes H2. The fuel jet adjusting plate 1 is formed as a slab.

As with the first embodiment, the valve body is disposed in an upper part of Fig. 5, namely, above the fuel jet adjusting plate 1. The valve body is driven by driving means (not shown) between an open position and a closed position. When the valve body assumes the open position, fuel supplied from top to bottom in Fig. 5 reaches a location immediately upstream of the fuel jet adjusting plate 1 and flows toward the central axis L0, that is, in a radially outside-to-inside direction (See blank arrows in Fig. 5). In this case, the fuel flows toward the central axis L0 at a lower rate upstream of inlet portions of the nozzle holes H2 than upstream of inlet portions of the nozzle holes H1. That is, the flow rate of fuel becomes higher in the radially outside-to-inside direction.

Hence, as with the first embodiment, the fuel jet adjusting plate 1 of this embodiment has nozzle holes H1 arranged along the first circle C1 and nozzle holes H2

arranged along the second circle C2. In addition, the diameterD2 of the second nozzle holes H2 is smaller than the diameter D1 of the first nozzle holes H1.

Thus, despite the fact that fuel flows toward the central axis L0 of the valve body at a lower rate upstream of the inlet portions of the nozzle holes H2 than upstream of the inlet portions of the nozzle holes H1, the fuel jet adjusting plate 1 can suitably atomize the fuel spray F1 injected through the first nozzle holes H1 and the fuel spray F2 injected through the second nozzle holes H2 without inhibiting fuel from flowing upstream of the inlet portions of the nozzle holes H1. Hence, preventing deterioration of the performance of an internal combustion engine on which the fuel injection valve is mounted, whereby the amount of HC emissions can be reduced.

Referring further to Fig. 5, in this embodiment, the respective hole axes L1 of the nozzle holes H1 form an acute angle a1 with the reference plane SB and the respective hole axes L2 of the nozzle holes H2 form an acute angle a2 with the reference plane SB. The acute angle a2 is smaller than the acute angle a1.

Hence, the fuel spray F1 injected through the nozzle holes H1 and the fuel spray F2 injected through the nozzle holes H2 are directed away from each other. Therefore, the fuel spray F1 injected through the nozzle holes H1 does not interfere with the fuel spray F2 injected through the nozzle holes H2. As a result, it is possible to stabilize the fuel spray injected through the respective nozzle holes and suitably atomize the injected fuel. In addition, despite the fact that fuel flows at a lower rate upstream of the inlet portions of the nozzle holes H2 than upstream of the inlet portions of the nozzle holes H1, the fuel spray F2 injected through the nozzle holes H2 can suitably be atomized. This is because the acute angle a2 is smaller than the acute angle a1.

While the present invention has been described with reference to what are presently considered to be preferred

embodiments thereof, it is to be understood that the invention is not limited to the disclosed embodiments or constructions. On the contrary, the invention is intended to cover various modifications and equivalent arrangements. In addition, while the various element of the disclosed invention are shown in various combinations and configurations, which are exemplary, other combinations and configurations, including more, less or only a single element, are also within the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A fuel injection valve for an internal combustion engine, comprising:

a valve body driven by a driving device between an open position and a closed position;

a fuel jet adjusting plate for atomizing fuel injected when the valve body assumes the open position;

a plurality of first nozzle holes formed in the fuel jet adjusting plate and arranged along a first circle coaxial with a central axis of the valve body; and

a plurality of second nozzle holes formed in the fuel jet adjusting plate and arranged along a second circle coaxial with the central axis, wherein a diameter of the second circle is larger than a diameter of the first circle, the second nozzle holes having an opening area smaller than an opening area of the first nozzle holes.

2. The fuel injection valve according to claim 1, wherein each of the first nozzle holes extends through the fuel jet adjusting plate along a respective first hole axis and wherein a first acute angle is formed between the first hole axes and a plane of the fuel jet adjusting plate, each of the second nozzle holes extending through the fuel jet adjusting plate along a respective second hole axis and wherein a second acute angle is formed between the second hole axes and the plane of the fuel jet adjusting plate, the first and second angles being different from each other.

3. The fuel injection valve according to claim 2, wherein the second acute angles are smaller than the first acute angles.

ABSTRACT OF THE DISCLOSURE

A fuel jet adjusting plate has first nozzle holes arranged along a first circle coaxial with a central axis of a valve body and second nozzle holes arranged along a second circle coaxial with the central axis and having a diameter larger that the first circle. The second nozzle holes have an opening area smaller than that of the first nozzle holes. Thus, despite the fact that fuel flows at a lower rate upstream of inlet portions of the second nozzle holes than upstream of inlet portions of the first nozzle holes, it is possible to suitably atomize both the fuel spray injected through the first nozzle holes and the fuel spray injected through the second nozzle holes.

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FIG. 1

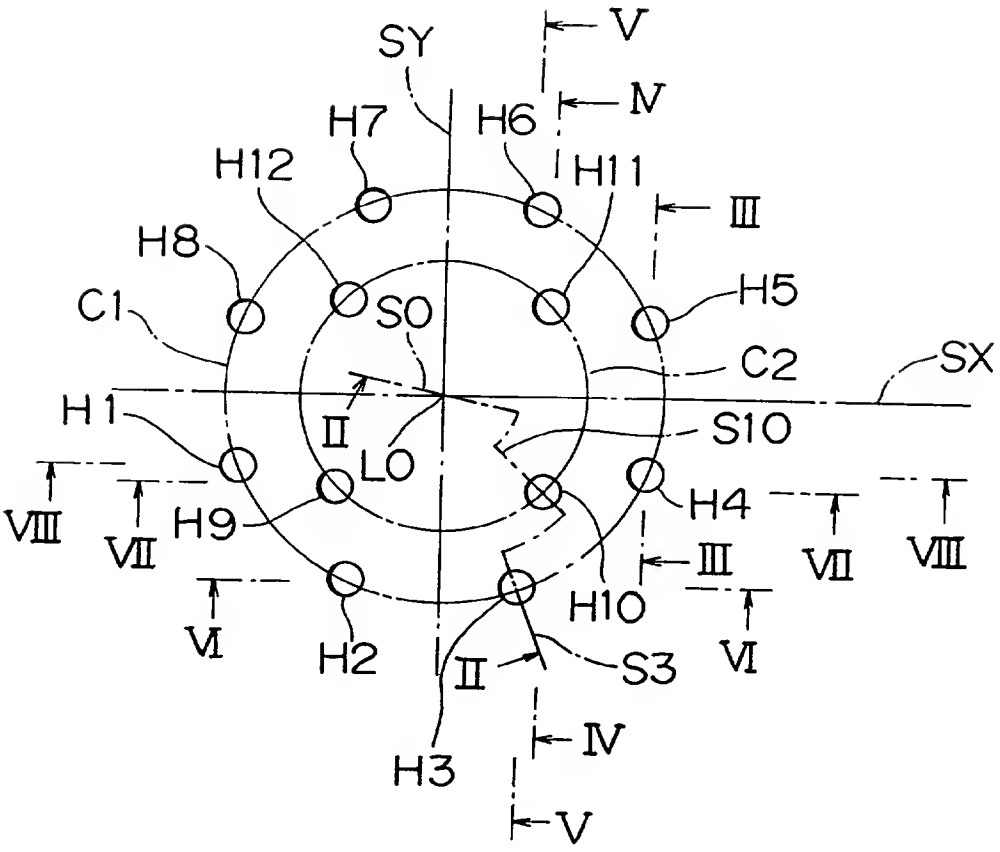


FIG. 2

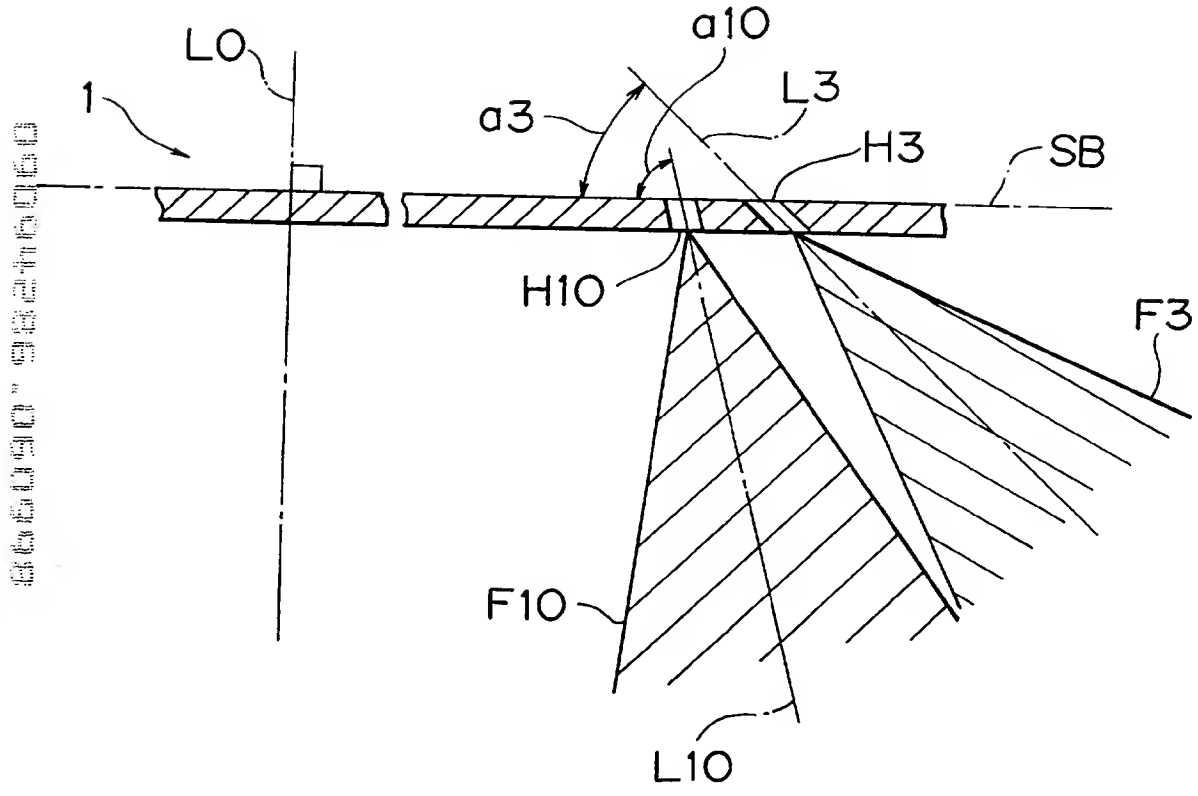


FIG.3

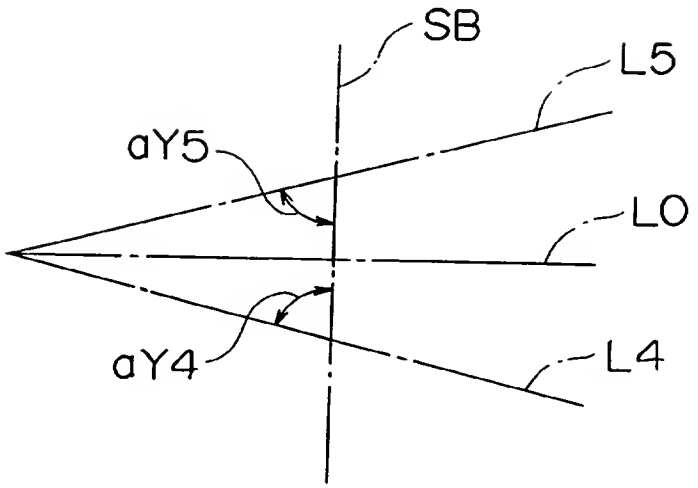


FIG.4

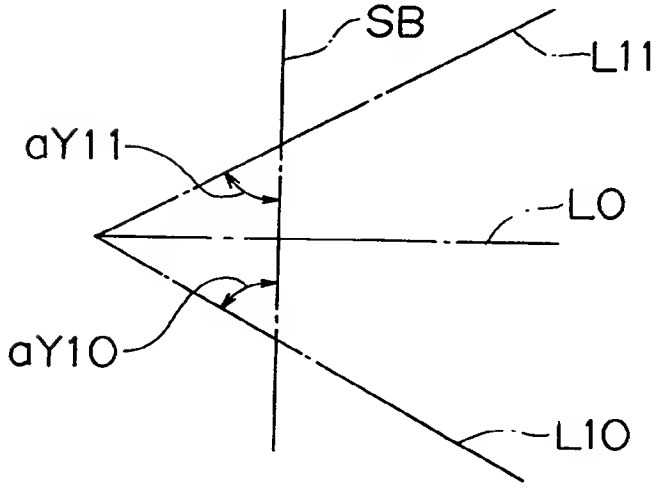


FIG.5

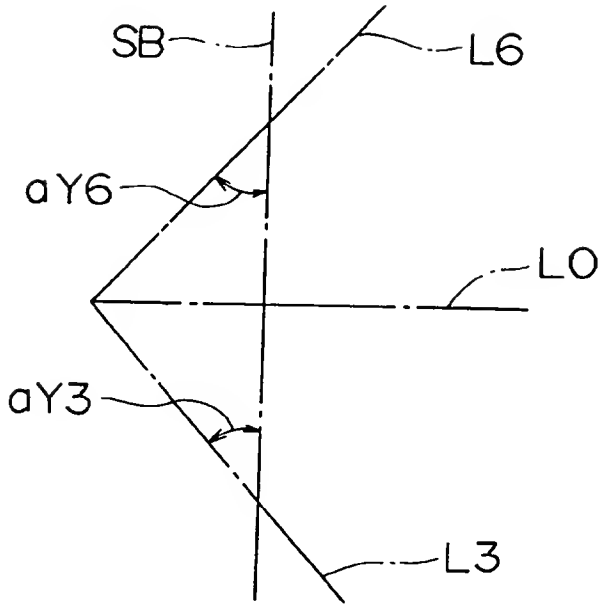


FIG.6

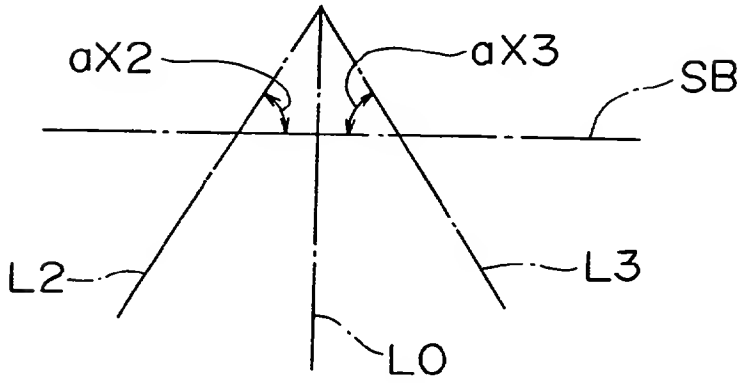


FIG. 7

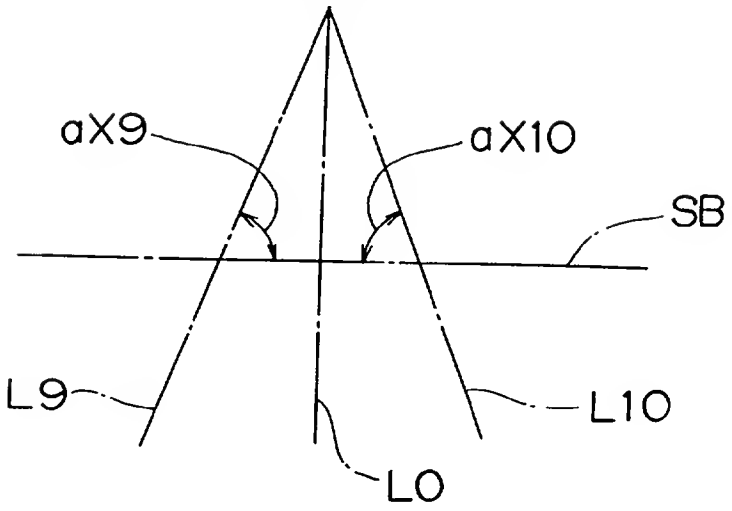


FIG. 8

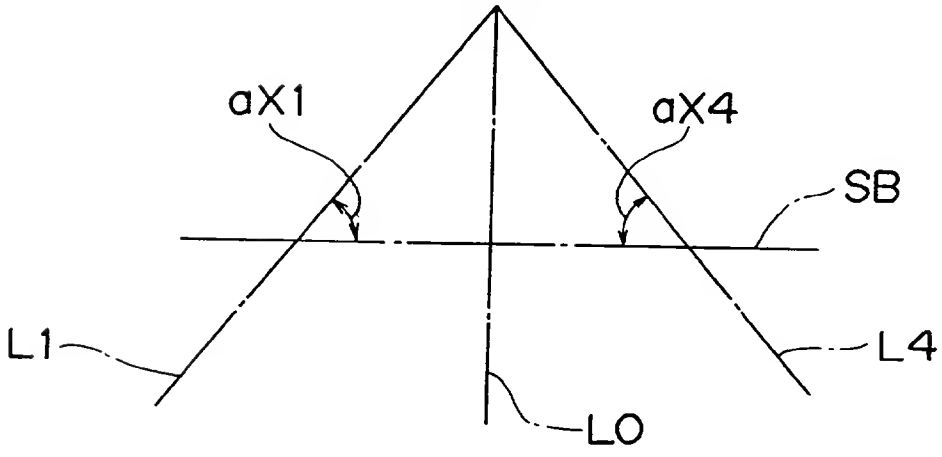
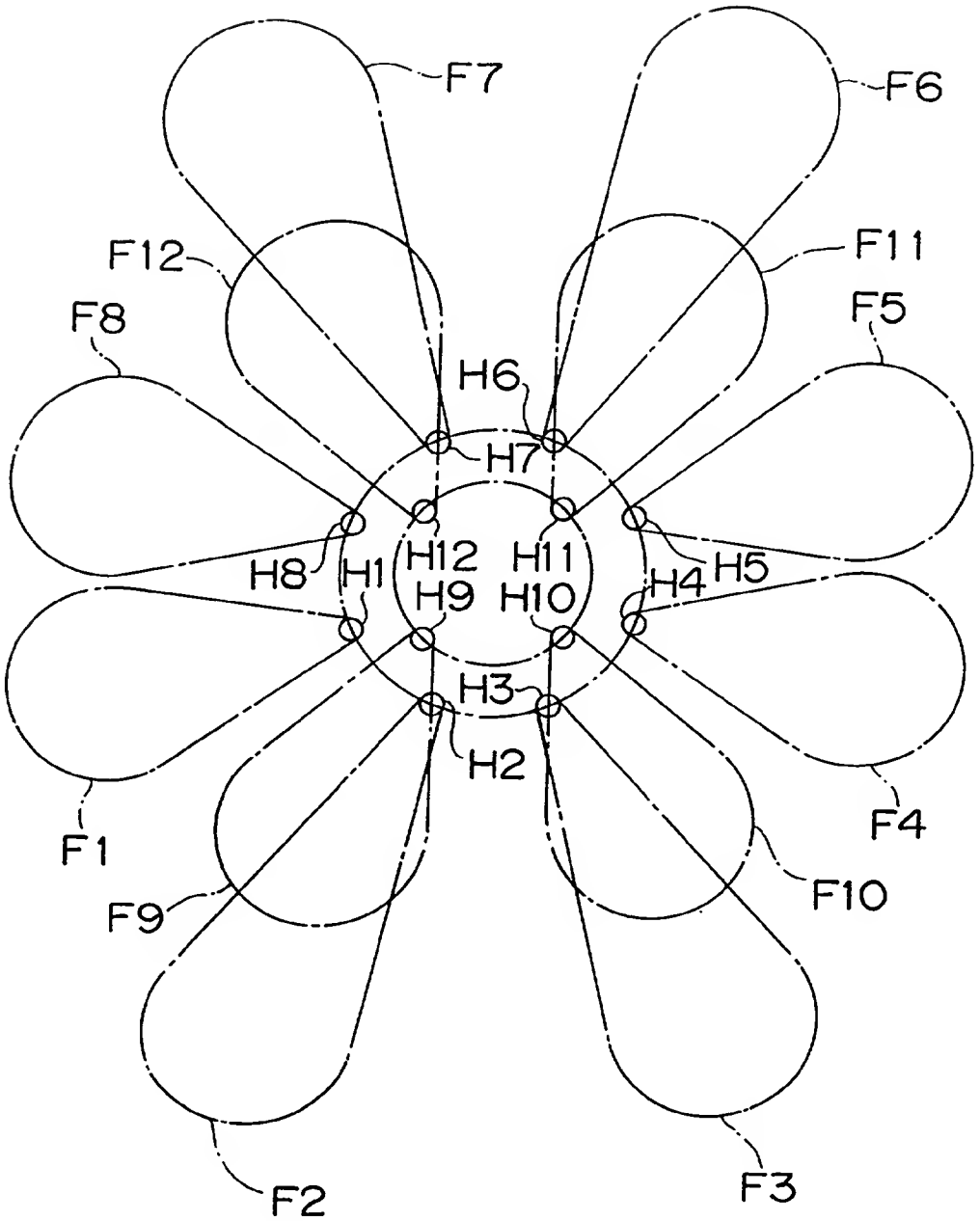


FIG. 9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H11
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H2
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FIG.10

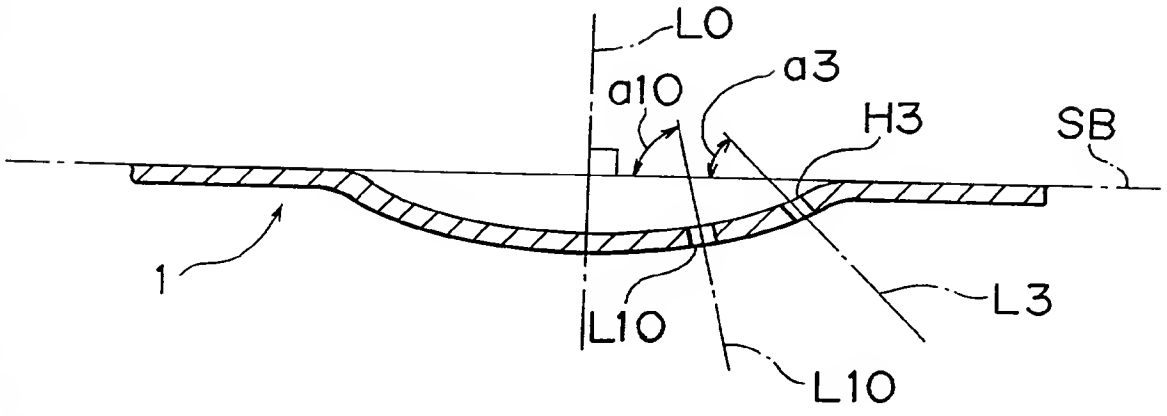

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FIG. 11

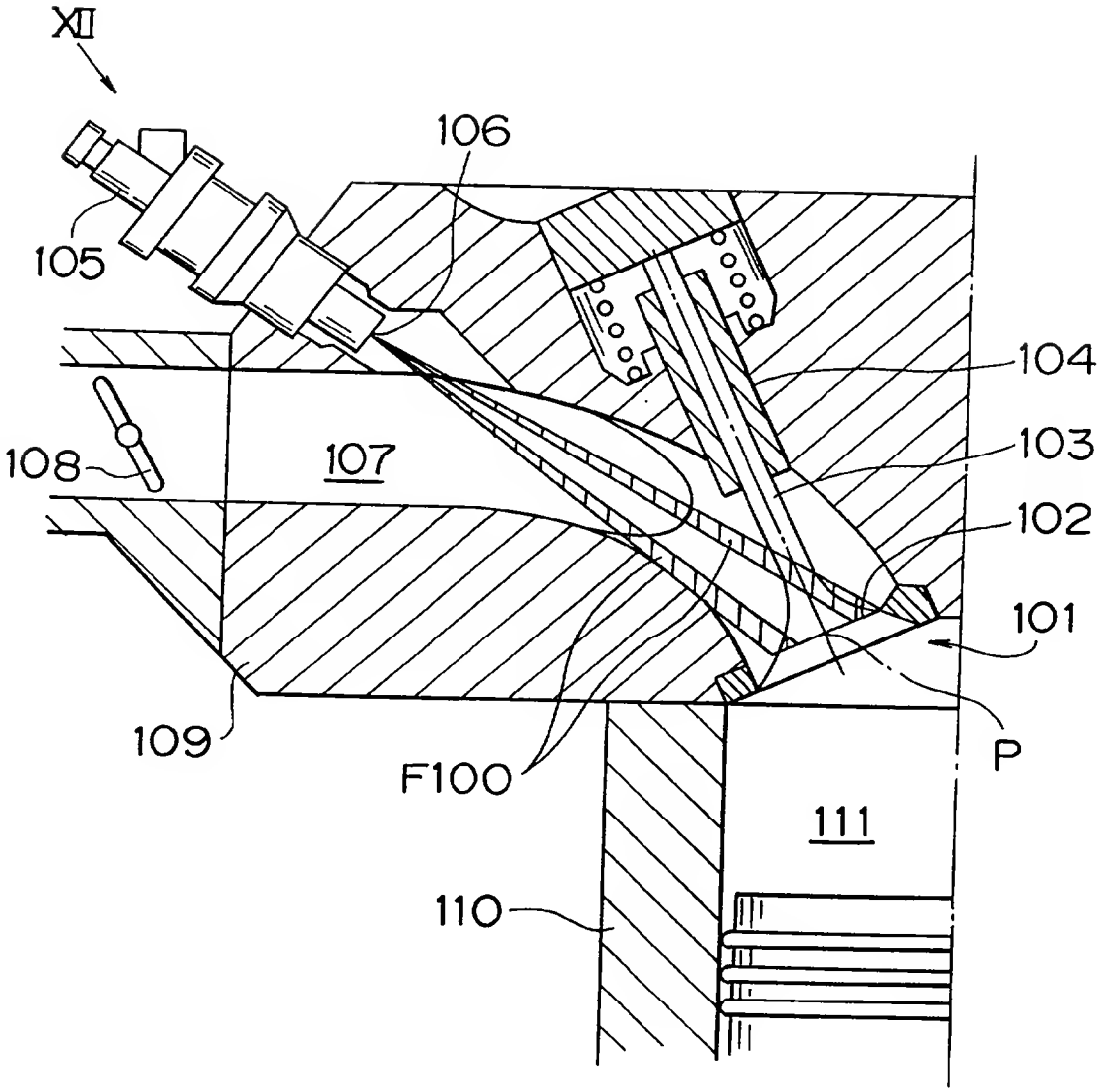

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FIG. 12

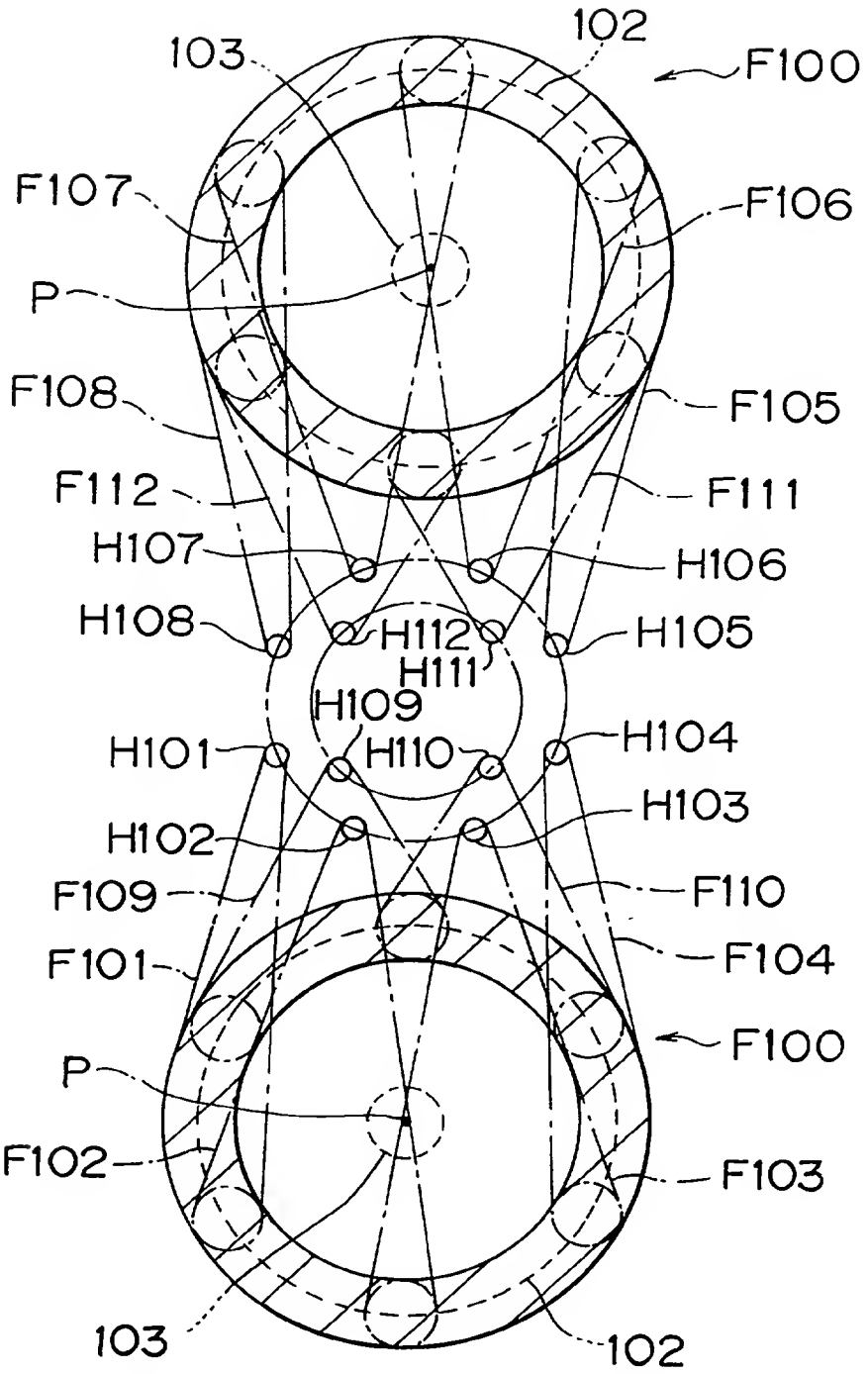

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FIG. 13

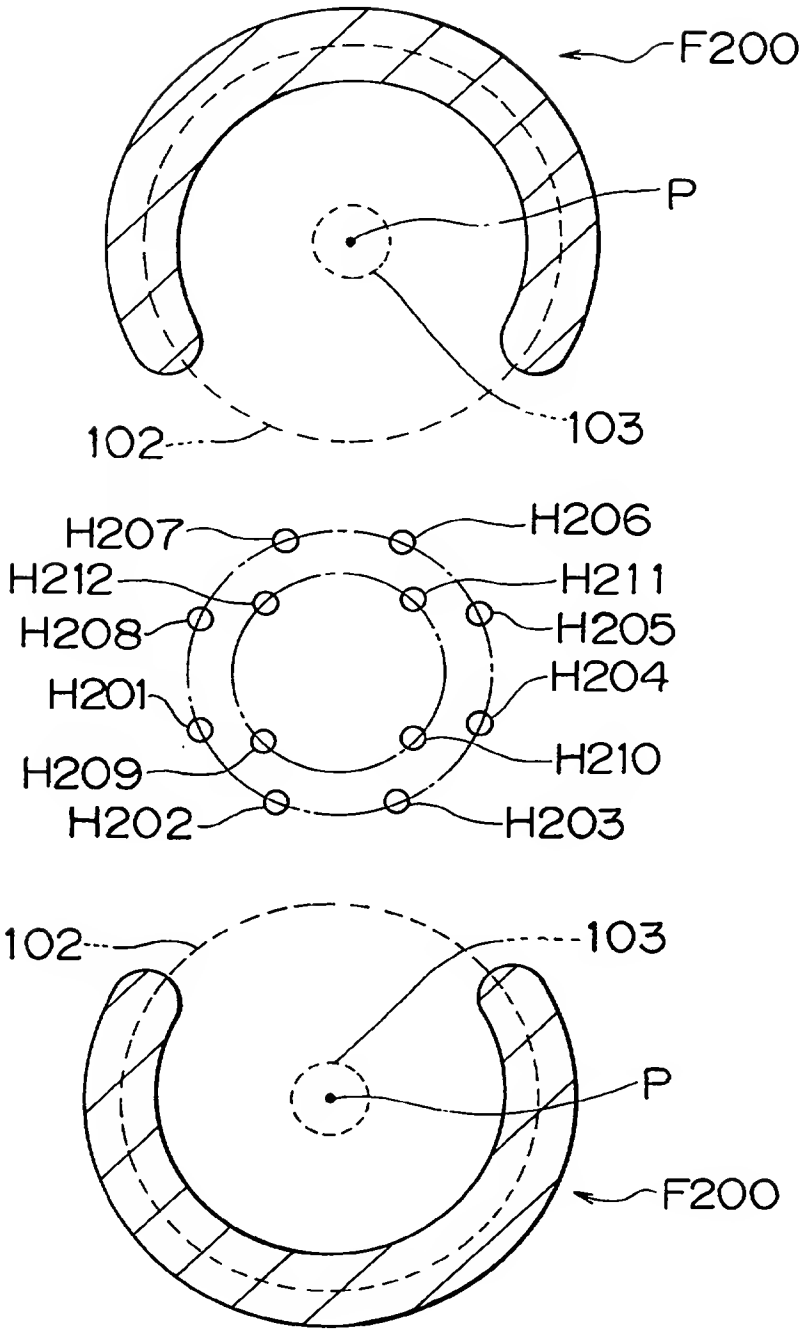

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FIG. 14

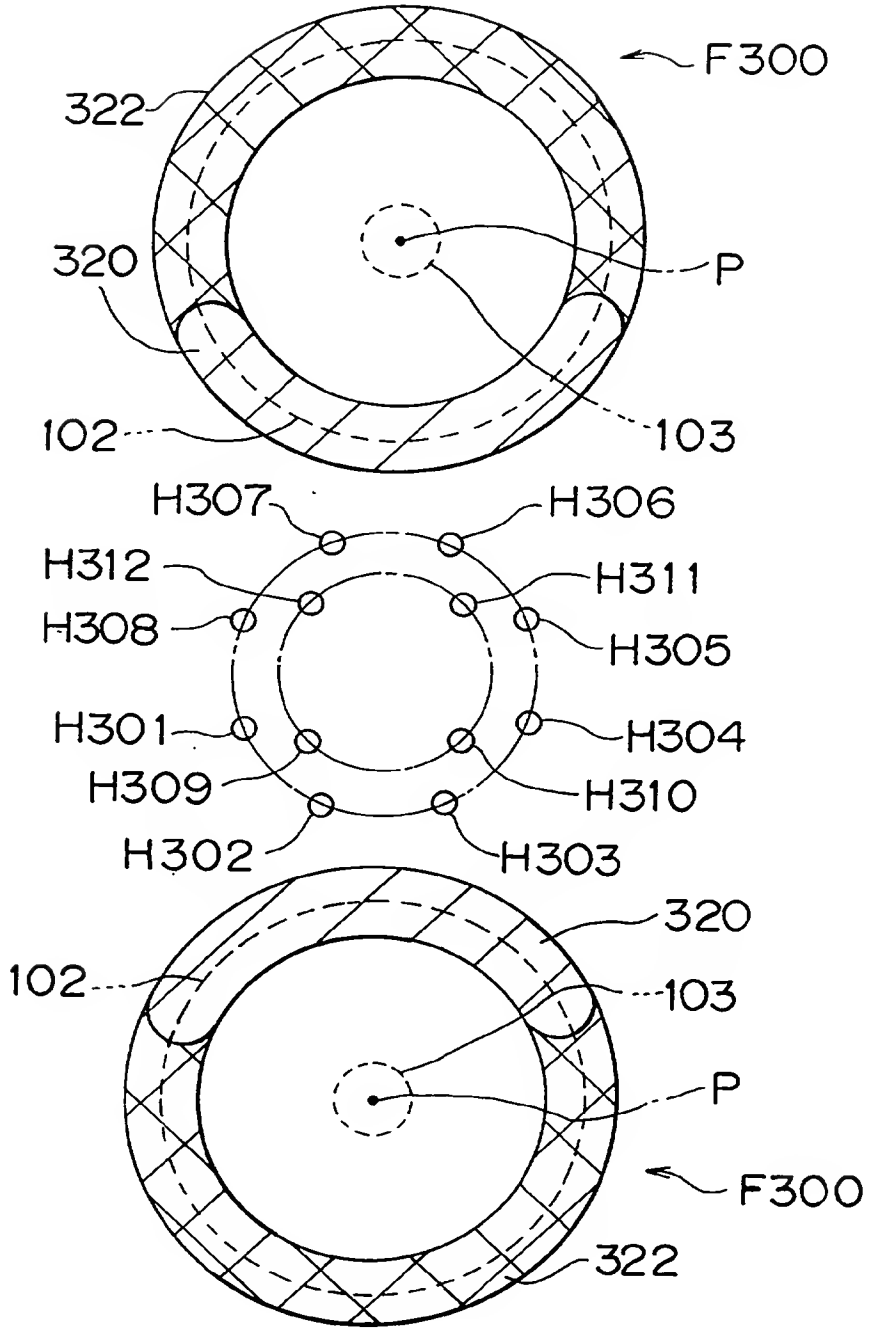

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FIG. 15

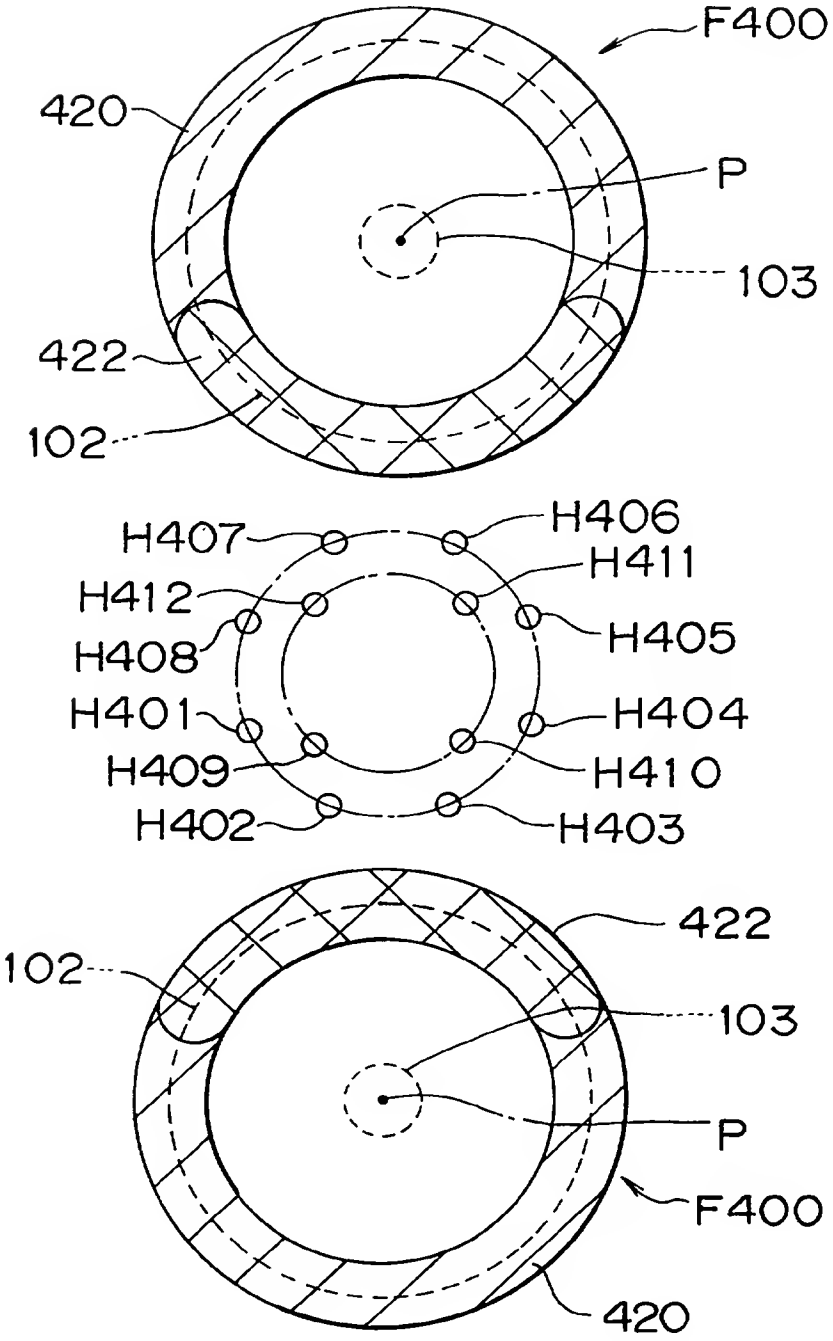

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FIG. 16

RELATED ART

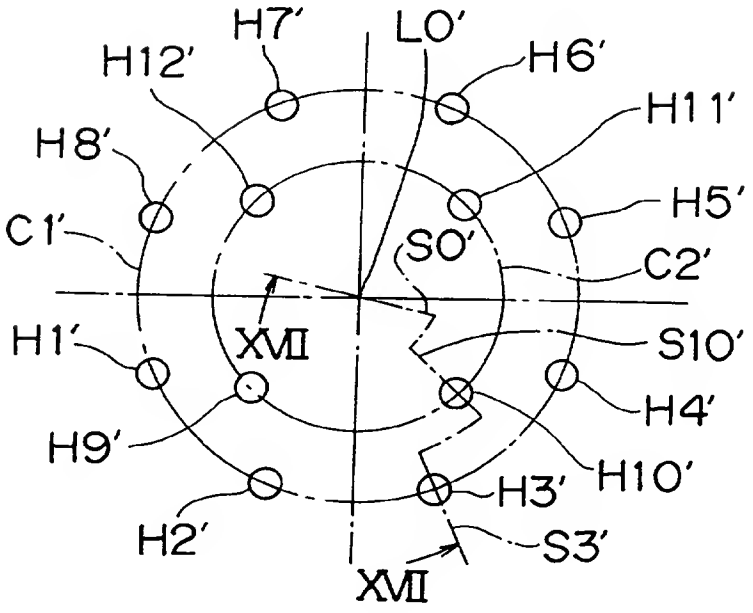

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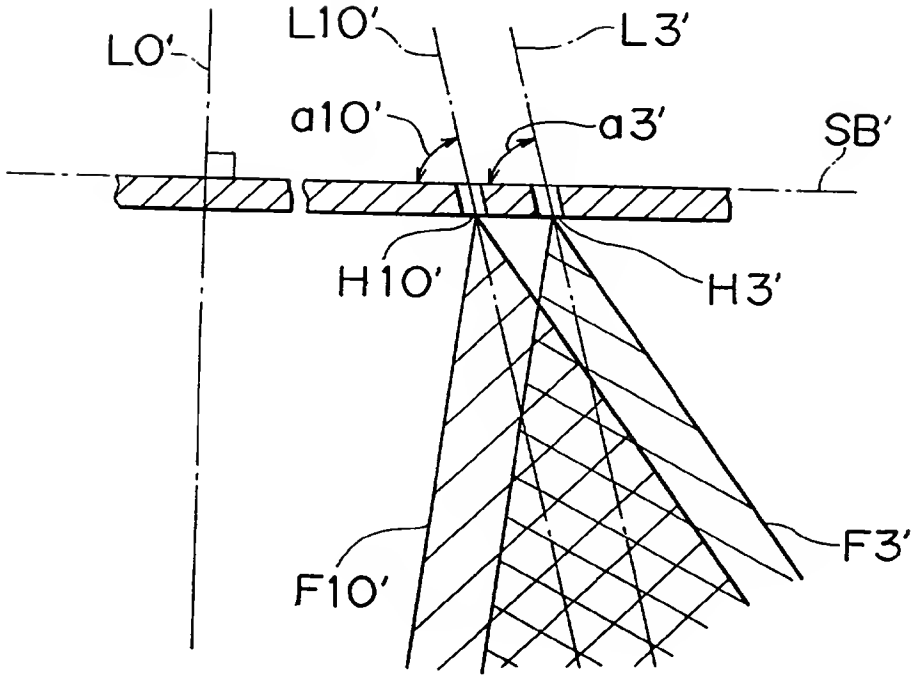
FIG. 17

RELATED ART



DECLARATION AND POWER OF ATTORNEY – ORIGINAL APPLICATION	ATTORNEY'S DOCKET NO. 10517/4

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled FUEL INJECTION VALVE FOR AN INTERNAL COMBUSTION ENGINE

the specification of which

(check one)

X is attached hereto.

____ was filed on _____ as Application Serial No. _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
Japan	9-167629	24/06/1997		☒ YES ☐ NO
Japan	9-310500	12/11/1997		☒ YES ☐ NO

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

APPLICATION NO.	FILING DATE (day, month, year)	STATUS (i.e. Patented, Pending, Abandoned)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

Edward W. Greason, Esq.
Reg. No. 18,918

SEND CORRESPONDENCE TO:	DIRECT TELEPHONE CALLS TO: *(name and telephone number)*
KENYON & KENYON One Broadway New York, New York 10004	Edward W. Greason (212) 425-7200 X108

(continued)

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	POST OFFICE ADDRESS	POST OFFICE ADDRESS: c/o TOYOTA JIDOSHA KABUSHIKI KAISHA 1, Toyota-cho,	CITY: Toyota-shi	STATE & ZIP CODE/COUNTRY: Aichi-ken, 471-8571, Japan
202	FULL NAME OF INVENTOR	FAMILY NAME: TAKEDA	FIRST GIVEN NAME: Keiso	SECOND GIVEN NAME:
	RESIDENCE & CITIZENSHIP	CITY: Mishima-shi	STATE OR FOREIGN COUNTRY: Japan	COUNTRY OF CITIZENSHIP: Japan
	POST OFFICE ADDRESS	POST OFFICE ADDRESS: c/o TOYOTA JIDOSHA KABUSHIKI KAISHA 1, Toyota-cho	CITY: Toyota-shi	STATE & ZIP CODE/COUNTRY: Aichi-ken, 471-8571, Japan
203	FULL NAME OF INVENTOR	FAMILY NAME:	FIRST GIVEN NAME:	SECOND GIVEN NAME:
	RESIDENCE & CITIZENSHIP	CITY:	STATE OR FOREIGN COUNTRY:	COUNTRY OF CITIZENSHIP:
	POST OFFICE ADDRESS	POST OFFICE ADDRESS:	CITY:	STATE & ZIP CODE/COUNTRY:
204	FULL NAME OF INVENTOR	FAMILY NAME:	FIRST GIVEN NAME:	SECOND GIVEN NAME:
	RESIDENCE & CITIZENSHIP	CITY:	STATE OR FOREIGN COUNTRY:	COUNTRY OF CITIZENSHIP:
	POST OFFICE ADDRESS	POST OFFICE ADDRESS:	CITY:	STATE & ZIP CODE/COUNTRY:
205	FULL NAME OF INVENTOR	FAMILY NAME:	FIRST GIVEN NAME:	SECOND GIVEN NAME:
	RESIDENCE & CITIZENSHIP	CITY:	STATE OR FOREIGN COUNTRY:	COUNTRY OF CITIZENSHIP:
	POST OFFICE ADDRESS	POST OFFICE ADDRESS:	CITY:	STATE & ZIP CODE/COUNTRY:
206	FULL NAME OF INVENTOR	FAMILY NAME:	FIRST GIVEN NAME:	SECOND GIVEN NAME:
	RESIDENCE & CITIZENSHIP	CITY:	STATE OR FOREIGN COUNTRY:	COUNTRY OF CITIZENSHIP:
	POST OFFICE ADDRESS	POST OFFICE ADDRESS:	CITY:	STATE & ZIP CODE/COUNTRY:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
Tomojiro Sugimoto	Keiso Takeda	
DATE: 18 May, 1998	DATE: 18 May, 1998	DATE:
SIGNATURE OF INVENTOR 204	SIGNATURE OF INVENTOR 205	SIGNATURE OF INVENTOR 206
DATE:	DATE:	DATE: